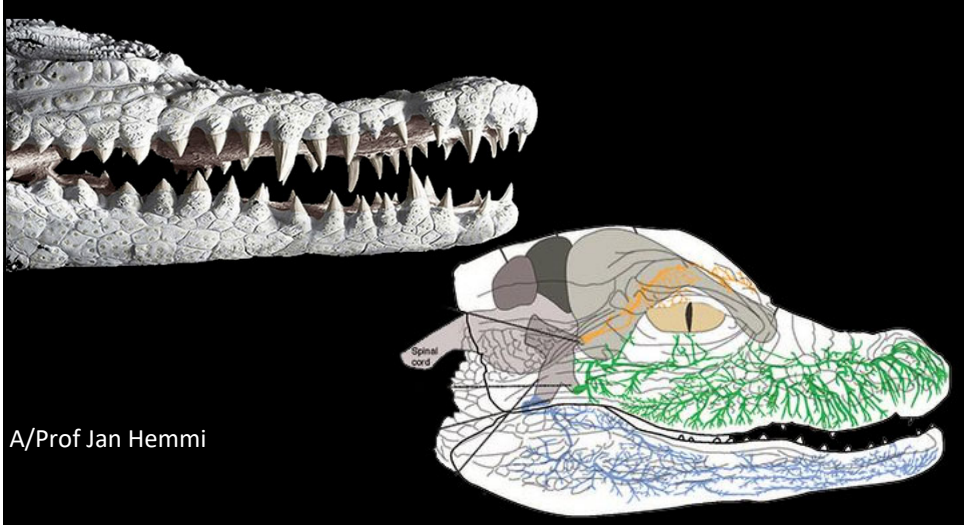
Mechanoreception: 1. Overview



A/Prof Jan Hemmi

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Overview

- What is mechanoreception and how does it work?
- Examples of “inner” mechanoreception
  - Hearing
  - Sense of equilibrium (function, occurrence in aquatic animals, dorsal light reflex, flatfish problems)
  - Proprioreception - what’s happened to my body?
- Mechanoreception in action: the fast response

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Mechanical stimuli

- External stimuli: touch, pressure, vibration, water currents and sound
  - Ear and somatosensory system
- Internal stimuli: contraction of muscles, limb flexion, pressure on blood vessels, osmolarity
  - Proprioception
- Gravity and Acceleration
  - Equilibrium organs (statolith organ, vestibular organ)

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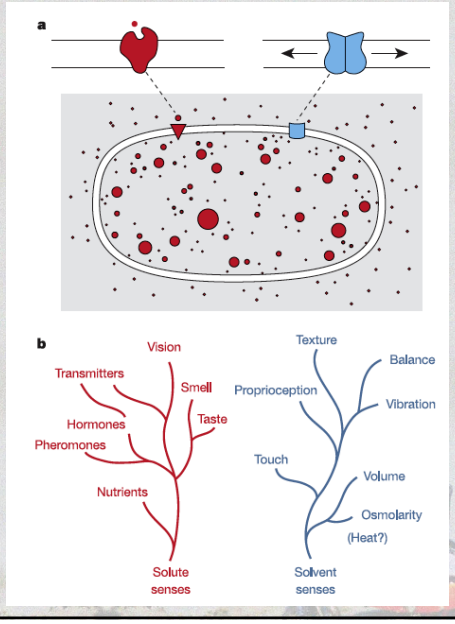
Evolutionary explanation for the way receptors work

- Based on procaryotic need to sense of the world
  - Solute sensing: for molecules (ligands) dissolved in water: lock & key mechanism (red)
  - Solvent sensing: sensing force by the water: turgor sensors (blue)
- Trees (not a phylogenetic tree!) show both distinct groups of senses based on their fundamentally different detection of external stimuli.



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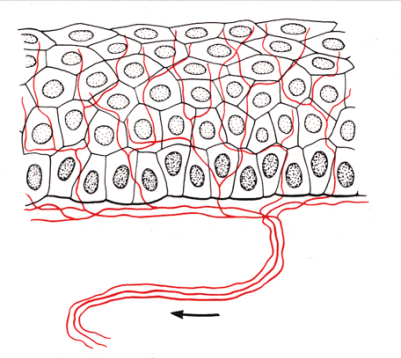
Mechanoreceptors I

Receptors without cilia

- Free nerve endings (detect pain)
- Crustacean stretch receptors
- Touch receptors vertebrate and invertebrate
- Spindle organs (vertebrate muscle)
- Receptive to: touch, pressure, acceleration or stretching of muscle/tendon
- Temperature



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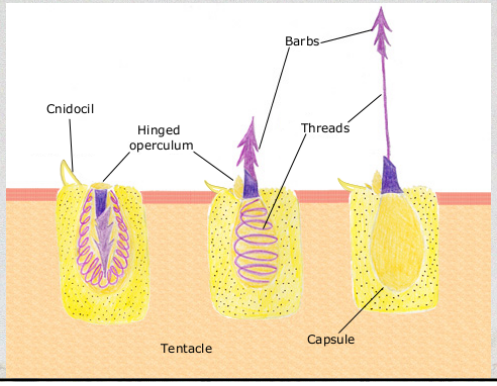
Mechanoreceptors II

Receptors with cilia

- Cnidarian nematocysts, inner ear, lateral line organs, tactile hair (arthropods)
- Receptive to: touch and pressure, hearing, balance, vibration, water flow



http://en.wikipedia.org/wiki/File:Nematocyst_discharge.png

Cilia
(hair cells)

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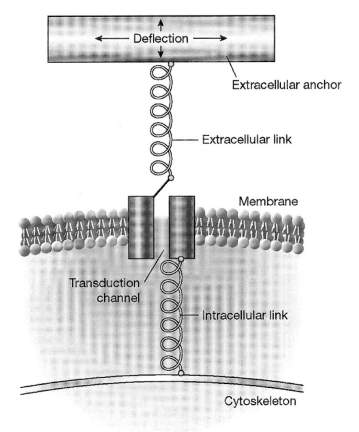
Mechanotransduction

How it works

- High speed response (no second messengers): latency ~ tens of µs → 1000 times faster than photoreceptor
- Tripping the ion channel to change receptor potential:
  - Tethers (i.e. in haircells) affect channel conformation
  - Direct force on the lipid bilayer of the membrane around the channel changes channel conformation



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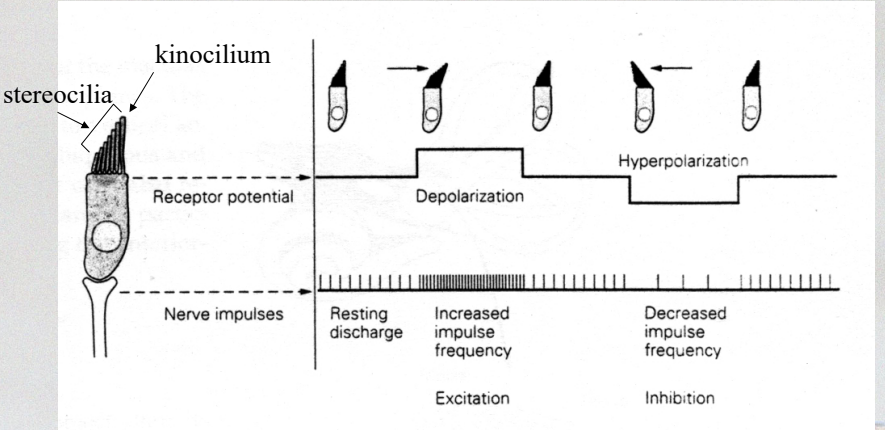
Mechanotransduction

Neural signals of hair cells



Movement required by hair cells: 0.3nm! = 1000 times less then wavelength of UV light

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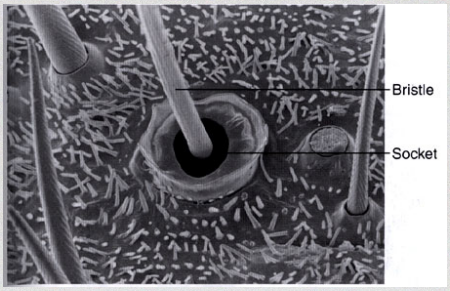
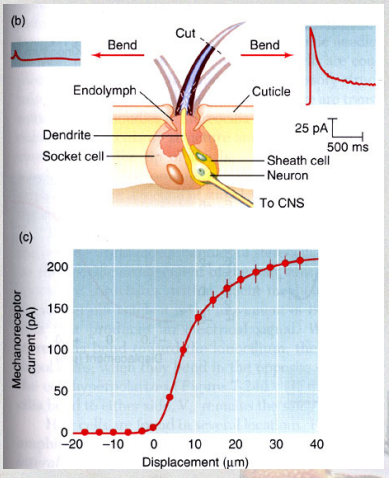
Mechanotransduction

Neural signals - insect bristle

Cricket hair



Drosophila bristle



Directional response